Combining Quasi-Orthogonal Space-Time Coding and Antenna Selection in MIMO-Systems

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We present a method to combine Quasi-Orthogonal Space-Time Codes (QSTBCs) for 4 transmit antennas with antenna selection [1] to achieve high diversity order with a simple decoding algorithm on uncorrelated and correlated multiple input/multiple output (MIMO) channels. Our selection rule minimizes the average Bit Error Ratio (BER) and improves the system diversity even if only a simple zero-forcing (ZF) receiver is used. We show that using the best antenna subset from more than 4 available transmit antennas we can substantially improve diversity and the coding gain of space-time code compared to the case when only 4 transmit antennas are used. We consider a $n_t \times n_r$ MIMO channel and assume quasi-static flat Rayleigh fading. The channel coefficients $h_{i,j}$ are modelled as complex zero mean Gaussian random variables with unit variance, i.e. $h_{i,j} \sim N(0,1)$. We assume perfect channel knowledge at the receiver and partial channel knowledge at the transmitter provided by a low feedback rate. For transmission we use the QSTBC for $n_t = 4$ and $n_r = 1$ [2] where four symbols s_1 to s_4 are transmitted in four time slots:

$$\mathbf{S} = \begin{bmatrix} s_1 & s_2 & s_3 & s_4 \\ s_2^* & -s_1^* & s_4^* & -s_3^* \\ s_3^* & s_4^* & -s_1^* & -s_2^* \\ s_4 & -s_3 & -s_2 & s_1 \end{bmatrix}; \qquad (1)$$

The transmission is described by $\mathbf{y} = \mathbf{S}\mathbf{h} + \mathbf{v}$, where $\mathbf{S}$ is the code matrix, $\mathbf{y}$ is the $(n_t \times 1)$ vector of signals received at the single receive antenna in n_t time slots and $\mathbf{v}$ is the $(n_t \times 1)$ complex Gaussian noise vector. By complex conjugation of the second and third element of $\mathbf{y}$, as already described in [3], the transmission can be reformulated as $\tilde{\mathbf{y}} = \mathbf{H}_v \mathbf{s} + \tilde{\mathbf{v}}$, where $\mathbf{H}_v$ is an equivalent 4×4 virtual channel matrix consisting of scrambled and conjugated values of $h_{i,j}$. We assume that $n_t \geq 4$ antennas are available at the transmitter and $n_r = 1$ antenna is used at the receiver. We assume that the transmitter selects only four out of n_t transmit antennas at each fading block transmitting the QSTBC over 4 properly selected transmit antennas. The selection goal is to transmit over the optimal antenna subset. The receiver selects the optimal antenna subset and sends this information back to the transmitter. The QSTBC is than transmitted over this antenna subset. To find an optimum selection criterion we have to analyze the performance of the system. On the receiver side, after matched filtering, we use the ZF receiver: $\hat{\mathbf{y}} = (\mathbf{H}_v^H \mathbf{H}_v)^{-1} \tilde{\mathbf{y}}$. It is well known that this linear receiver causes noise enhancement and diversity loss. The BER function for the ZF receiver with QSTBC transmission is given by [3] $\text{BER}_{ZF} \sim \text{erfc}(\sqrt{(h^2(1-X^2)/\sigma_v^2})$. Therefore the optimum antenna subset maximizes the term $h^2(1-X^2)$. h^2 and X depend on the channel transfer functions h_{ij} and are defined in [3].

We have simulated the BER as a function of E_b/N_0 using 4QAM symbols leading to an information rate of 2 bits/channel use. We simulated MIMO systems with $4 \leq n_t \leq 7$ and $n_r = 1$. In case of correlated channels we modeled fading correlation by the Kronecker Model [4]. Fig. 1 presents simulation results for the i.i.d. channel. Both coding and diversity gain are strongly improved with an increasing number of available transmit antennas. Fig. 2 shows the simulation results in case of highly correlated MIMO channels. Obviously the QSTBC improves the transmission very similar to the behavior of an i.i.d system without antenna selection. However, due to the strong spatial correlation antenna selection leads only to a small additional improvement. Additional results will be presented at the conference.

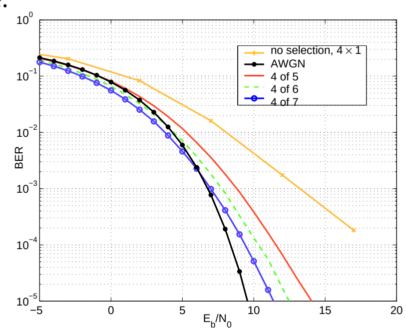

Fig. 1. Antenna Selection, Spatially Uncorrelated Channels

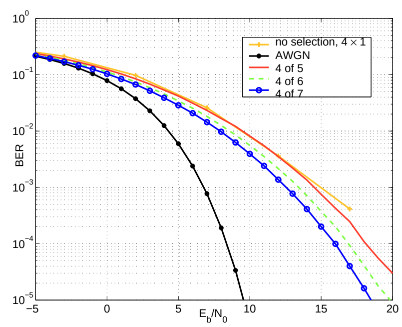

Fig. 2. Antenna Selection, Spatially Correlated Channels, $\rho = 0.95$

References

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